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COLLEGE OF AGRICULTURAL AND
ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION

AQUACULTURE AND FISHERIES PROGRAM
3202 MEYER HALL
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA 95616
(916) 752-7601
FAX: (916) 752-4508

July 28, 1997

CALFED Bay-Delta Program
1416 Ninth Street
Sacramento, CA 95814

Dear CALFED Panel,

Please find enclosed our proposal on the development of delta smelt culture to support environmental studies. We are also attaching the letters from Professors J. Cech and D. Hinton's laboratories expressing their interest in our project.

We appreciate your consideration of the proposal.

Sincerely,

Serge Doroshov, Director
Aquaculture & Fisheries Program

SD:ng

Enclosures

I-004024

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OFFICE OF THE VICE CHANCELLOR FOR RESEARCH
(916) 752-2075
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DAVIS, CALIFORNIA 95616-8671

JUL 28 1997

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento CA 95814

Research Proposal Entitled
"Determining Optimal Migratory Conditions for Juvenile Chinook Salmon and Steelhead Trout"
RFP: 1997 Category III Ecosystem Restoration Projects and Programs
Principal Investigator - J.J. Cech

Dear Colleague:

It is our pleasure to present for your consideration the referenced proposal in response to **the CALFED Bay-Delta Program RFP.**

Please call on the principal investigator for scientific information. Administrative questions may be directed to me or my assistant, René Domino, at the above address and phone number. We request that correspondence pertaining to this proposal and a subsequent award be sent to the Office of Research and to the principal investigator.

Sincerely,

Sandra M. Dowdy
Contracts and Grants Analyst

Enclosure

cc: J.J. Cech

97 JUL 28 PM 3:02
DWR MANAGEMENT

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I. Executive Summary/Inquiry Submittal Format

a. Research *Proposal Title:* **Determining Optimal Migratory Conditions for Juvenile Chinook Salmon and Steelhead Trout**

Investigators: Joseph J. Cech, Jr. and Shana M. Katzman
Department of Wildlife, Fish and Conservation Biology
University of California, Davis
Davis, California 95616

b. *Project Description and Primary Biological/Ecological Objectives*: Past water management practices have contributed to the decline of Pacific salmon and steelhead stocks in California's Sacramento-San Joaquin ecosystem. Barriers, including dams and reservoirs have produced water quality problems, such as decreased flow and increased temperatures impacting young migrating salmonid fishes. While various means have been employed to halt the salmonid population declines, improvement of downstream migration is perhaps the best opportunity to increase salmonid recruitment and prevent extinction. During the parr-smolt transformation a young anadromous salmon or trout will migrate downstream to the estuary and eventually swim to the ocean. Interestingly, studies on both the Pacific and Atlantic salmon have found an increase in swimming performance as parr grow larger and then a decrease in swimming performance during the transformation from parr to smolt. Decreased swimming performance may reflect structural/functional changes in swimming muscle and signal the optimal time for migration. Changes in muscle proteins and development during smoltification have been described in hatchery-raised Atlantic salmon (*Salmo salar*) (Higgins,1990; Higgens and Thorpe,1990)but these changes were not coupled with physiological indices of swimming performance. What is needed is a comprehensive study to quantitatively evaluate likely water and Pacific salmonid management strategies. Specifically, water and salmonid managers need better indicators of proper chinook salmon and steelhead migratory readiness in wild stocks, smolt release timing from hatcheries, and better timing of reservoir water releases to maximize smolt survival during migration.

Our objective is to quantitatively determine the optimal migratory conditions for juvenile chinook salmon and steelhead trout. Specifically, we will: 1. measure swimming muscle structure and function characteristics during the parr-smolt developmental transformation 2. determine effects of temperature on this development, and 3. determine swimming performance and velocity preferences for juvenile fall run chinook and steelhead at the same developmental stages. These data will delineate proper timing for efficient matching of stream conditions (temperature and flow, from reservoir water releases) with wild juvenile salmonid migratory movements and with smolt releases from hatcheries.

Approach/ Tasks/ Schedule: Fall-run chinook salmon and steelhead trout will be obtained in the first year of the project from Mokolumne hatchery. During the last two years of the project fall-run chinook salmon and steelhead trout will be collected (minnow seine, Archimedes screw traps) from the American River three times during the April-mid June stream rearing/smoltification period. Critical swimming velocities will be determined, using a recirculating, swimming flume and standard techniques. Blood lactate measurements will be taken by caudal severance after the fish has been fatigued. All experiments will be videotaped and analyzed for swimming kinematic data. A subsample of non-experimental and post-experimental fish will be sacrificed by a cranial blow and transection of the spinal cord. Strips of axial and pectoral swimming muscles will be tested for contraction force/velocity relationships at two temperatures (14 and 19 C). Histochemical stains will be used to identify muscle fiber muscle fiber type and morphology. After each experiment, presumed saltwater readiness (smoltification) will be determined using gill Na^+-K^+ -ATPase activity (Zaugg, 1989) . A flow table with a calibrated, horizontal velocity gradient will be used with a video camera (and night vision equipment) to determine juvenile chinook and steelhead velocity preferences and swimming behavior during lighted and darkened conditions. The range of available velocities will closely approximate natural stream conditions in the Sacramento-San Joaquin watersheds.

Together, these studies will be statistically analyzed to determine the structural/physiological capabilities, swimming performance envelope, and natural swimming patterns and velocity preferences of the parr-smolt transforming fish during migration.

d. *Justification for Project and Funding by CALFED*: Temperature-associated changes in muscle function, swimming performance, and velocity preference through smoltification should tightly link to downstream salmonid migrations. These links will delineate the proper timing for reservoir water and hatchery smolt releases to maximize smolt survival. The proposed studies will generate guidelines for stream temperature and flow criteria during smolt migration. Other studies have demonstrated that protein changes are occurring in the musculature during the parr-smolt transition. Quantification of these changes in terms of muscle microstructure and power generation can be used as a diagnostic tool for determining exactly when the smolts are prepared to migrate downstream. Hatcheries that now use Na^+-K^+-ATPase activity to assess smolt status, may be able to use a simple muscle biopsy and staining technique to determine the migratory (not just seawater) readiness. A more accurate method for determining the readiness of smolts to migrate should enhance the survival of the smolts, increase salmonid recruitment, and prevent extinction. Increased chinook salmon and steelhead populations would restore important living components of California's Delta ecosystem.

Budget Costs and Third Party Impacts:: $165,411 (for the three-year study). Equipment costs $22,320 (first year only) and personnel (approximately $25,000 to 27,000 per year for student assistance) constitute the major costs. This study will benefit both commercial and recreational salmonid fisheries and related economic structures as well as maintain an integral part of the California Native American cultural heritage.

Applicant Qualifications: Dr. Joseph J. Cech Jr., Ph.D. is a professor of Fisheries Biology at the University of California, Davis, and is a well-recognized authority on the physiology and ecological physiology of fishes. Ms. Shana Katzman holds a Master of Arts degree in Biology from UCLA, where she studied fish swimming under Prof. Malcolm Gordon's supervision.

Monitoring and Data Evaluation: Project results could be evaluated as soon as project recommendations are implemented by ongoing juvenile fish population monitoring programs (USFWS, CDFG, NMFS).

Local Support/Coordination with Other Programs/Capability with CALFED: Extensive local support is available for the three-year term of this project. Fish collection including hatchery fish will be assisted by the CDFG. University of California, Davis, is well known for its strong and diverse programs in biology. Seventeen professors at UCD are specialists in the field of fish biology. George Cardinet, a professor in the veterinary school, will be providing technical support for the histological studies. Steve Bennett in the Wildlife, Fish and Conservation Biology Department will be providing the hardware and software support. Further advice will be provided by scientists at the DWR and CDFG who are currently working with our laboratory on research concerning water diversions and fish screens. Presentation of results will be made at appropriate workshops and professional meetings.

This project enhances the two other Delta native fishes related investigations currently underway in our laboratory. One project involves the simulation of a large fish screen and observations of the kinematics and swimming performance of Delta fishes (including fall-run chinook parr) near the screen at various flow regimes and at 19 and 12 °C. Another student in the laboratory is beginning an investigation of hatchery steelhead growth and metabolic performance under various feeding regimes . The results of this proposed project will be combined with the results from the other two salmonid investigations to enhance understanding of the effects of anthropogenic influences on the native Delta fishes.

II. Title Page

a.*Research Proposal Title:* **Determining Optimal Migratory Conditions for Juvenile Chinook Salmon and Steelhead Trout**

b.*Investigators:* Joseph J. Cech, Jr. and Shana M. Katzman
Department of Wildlife, Fish and Conservation Biology
University of California, Davis
Davis, California 95616
(916) 752-3103, (916)752-8659, FAX:(916)752-4154
J.J. Cech@ucdavis.edu, smkatzman@ucdavis.edu

c. *Type of Organization and Tax Status*
State-assisted public research and educational university

d. *Tax Identification Number*
94-603-6494

e. *Technical and Financial Contact person(s), address, phone/fax/E-mail (if different from above)*
Technical: (same as above)
Financial: Ms. Marjorie Kirkman (same address as above)
(916)752-6584, FAX: (916)752-4154
makirkman@ucdavis.edu

f. *Participants/ Collaborators in Implementation*
California Department of Fish and Game, U.S. Fish and Wildlife Service, California Department of Water Resources, U.S. National Marine Fisheries Service

g. *RFP Project Group Types(s) (Construction; Acquisition; Other services)*
Fish monitoring/research

Sandra M. Dowdy
Contracts and Grants Analyst

III. Project Description

a. *Project description and Approach:*: Past water management practices have contributed to the decline of Pacific salmon and steelhead stocks in California's Sacramento-San Joaquin watersheds. Barriers, including dams and reservoirs have produced water quality problems such as decreased flows and increased temperatures, that negatively impact the migration of juvenile salmonids (NRC, 1996). While various means have been employed to halt the salmonid population declines, improvement of downstream migration is perhaps the best opportunity to increase salmonid recruitment and present extinction. During the parr-smolt transformation a young anadromous salmon or trout will migrate downstream to the estuary and eventually swim to the ocean. Many studies have demonstrated physiological changes, especially hormone levels, which accompany this transformation from a freshwater to a seawater type fish (review: Boeuf, 1993). Interestingly, studies on both the Pacific and Atlantic salmon have found an increase in swimming performance as parr grow larger and then a decrease in swimming performance during the transformation from parr to smolt. Decreased swimming performance (i.e., into river currents) should be adaptive for downstream migration, and it may reflect structural/functional changes in swimming muscle and signal the optimal time for migration. Changes in muscle proteins and development have been described in hatchery-raised Atlantic salmon (*Salmo salar*) (Higgins, 1990; Higgens and Thorpe, 1990), but these changes were not studied in conjunction with physiological indices of swimming performance such as muscle contraction kinetics, swimming performance or velocity preference. What is needed is a comprehensive study to quantitatively evaluate likely water and Pacific salmonid management strategies using optimal flow velocity and temperature parameters. Specifically, water and salmonid managers need better indications of proper salmonid migratory readiness in wild stocks and smolt release timing from hatcheries for better timing of reservoir water releases to maximize smolt survival during migration.

Our objective is to quantitatively evaluate various water/salmonid management possibilities, especially regarding the optimal timing of hatchery fall-run chinook and steelhead smolt releases. Specifically, we will: 1. measure swimming muscle structure and function characteristics during the parr-smolt developmental transformation. 2. determine effects of temperature on this development, and 3. determine swimming performance and velocity preferences for juvenile fall run chinook and steelhead at the same developmental stages. These data will delineate proper timing for efficient matching of stream conditions (temperature and flow, from reservoir water releases) with juvenile salmonid releases from hatcheries.

Approach/ Tasks/ Schedule: Fall-run chinook salmon and steelhead will be collected using minnow seine and Archimedes screw traps from the American River three times during the April-mid June stream rearing/smoltification period. Fish will be maintained at 14 and 19 C [(temperature fluctuations normally occurring in the stream system during the time of smoltification (D.T. Castleberry *et al.*, 1991)] in circular tanks at swimming speeds no greater than 1 body-length/sec. Critical swimming velocities will be determined, using a recirculating Brett-type swimming flume and standard techniques. Blood lactate measurements will be taken by caudal severance (Houston, 1990) after the fish has fatigued, to determine stress levels after swimming at high speeds. All experiments will be videotaped and analyzed with Peak Performance Software for kinematic data such as gait changes and tail-beat frequencies. After each experiment, presumed saltwater readiness (smoltification) will be determined using gill Na^+-K^+ -ATPase activity (Zaugg, 1989).

A subsample of fish (equal numbers of post-critical swimming speed experiment and unused animals) from the same size/developmental groups will be sacrificed with a cranial blow and transection of the spinal cord. Strips of abdominal and pectoral swimming muscles will be extracted. Muscle strips will be attached at one end to a force transducer and fixed in position at the other end in a temperature controlled Ringer's saline bath. The optimal length for force generation will be found by varying the length with a micromanipulator and stimulating the

muscle at various frequencies according to the kinematic data obtained from the critical swimming speed experiments. Force/velocity relationships will be determined in various measures of muscle kinetics (shortening speed, time to peak tension, time to relaxation) at acclimation temperatures of 14 and 19 °C. These experiments are important because the maximum isometric tension (P_0) and maximum contraction velocity (V_{max}) produced by a muscle fiber bundle is a function of both the absolute temperature at which it is tested as well as the acclimation temperature for the fish (Altringham and Johnston, 1984;1988). Experiments at two temperatures will determine the Q_{10} for the muscle fibers using the formula:

$$\log Q_{10} = (\log R_2 - \log R_1)\frac{10}{T_2 - T_1} \text{ (Neilsen, 1990)}$$

Where: R_2= contraction force (or velocity) at temperature 2 (T_2) and
R_1= contraction force (or velocity) at temperature 1 (T_1).
Muscle power generation (P) will be determined using the force/velocity relationships and the equation:

$$P=Fv$$

Where F= maximum isometric tension and
v = maximum contraction velocity (V_{max}).

After the muscle kinetics experiments, sarcomere length (at the peak tension fiber length) will be measured using a low power helium neon laser using Bragg's diffraction equation: sarcomere length= laser light wave length/sin where q= the angle delimited by the zero and first order diffraction line (Altringham and Johnston, 1994).

Histochemical stains will be used to identify various morphological and biochemical features of the muscle fibers from a subsample of fish. Trypan blue will be used to identify dead tissue from the muscle preparation (Sosnicki *et al.*, 1989). Cryosections will be prepared to assess enzymatic activity. Nitroblue tetrazolium with cyanide will be used to determine oxidative enzymes (Batty, 1983). Glycogen content will be assessed by the PAS reaction using Schiff's reagent (Dunn *et al.*, 1989). The volume of each fiber type and structural changes associated with development will be assessed with hematoxylin, eosin, Verhoeff, and van Gieson's stains. Sudan black will be used to examine tissue lipid content and distribution (Squire, 1986). These histological analyses will produce a quantitative assessment of fish condition, potential muscle power generation, including muscle fuel stores for migratory (sustained) and predator escape/prey capture burst activities.

A flow table with a calibrated, horizontal velocity gradient will be used with a video camera (and night vision equipment) to determine juvenile chinook and steelhead velocity preferences during lighted (and darkened) conditions. The range of available velocities will closely approximate natural conditions in the Delta and Sacramento- San Joaquin streams The age of individual salmon will be determined according to the length-otolith relationship:

$$\log L = \log(0.89196) + 0.93087 * \log(\text{RINGS})$$

where L=standard length and
RINGS=number of growth rings (D.T. Castleberry *et al.*, 1991).
Standard length will be measured after experiments are run and before blood samples are taken.

Together, these studies will delimit structural/physiological capabilities and the swimming performance envelope, as well as natural swimming patterns and velocity preferences of the parr-smolt transforming fish during migration to determine the optimal migratory conditions for juvenile chinook salmon and steelhead trout.

Appropriate statistical models will be used to analyze the data sets. Multiple analyses of variance (MANOVAs) will be used to compare muscle force generation at each frequency and

between age classes. A principal components analysis will be used to compare histological differences among age/development groups. MANOVA will be used to compare gait changes, critical swimming velocities, and velocity preferences among age/developmental groups.

Temperature-associated changes in muscle power and composition, kinetic performance, and velocity preference during smoltification should tightly link with downstream salmonid migrations. These links will delineate the proper timing for hatchery smolt releases and reservoir water releases to maximize smolt survival.

b. *Location and/or geographic boundaries of project:* Sacramento- San Joaquin ecosystem (Delta and contributing streams).

c. *Expected Benefits :* The proposed studies will generate guidelines for stream temperature and flow criteria during smolt migration. Other studies have demonstrated that protein changes are occurring in the musculature during the parr-smolt transition. Quantification of these changes in terms of muscle microstructure and power generation can be used as a diagnostic tool for determining exactly when the smolts are prepared to migrate downstream. Hatcheries that now use Na^+-K^+ -ATPase activity to assess smolt status, may be able to use a simple muscle biopsy and staining technique to determine the migratory (not just seawater) readiness. Fiber type determinations may also be used to determine the stream velocity (or location in the stream) at which the smolts can be released. Potential muscle power generation, and therefore smolt migratory readiness, can be assessed by examining fiber type and distribution. This information can be used to determine the timing and temperature of water release from dams during critical salmonid life history stages. A more accurate method for determining the readiness of smolts to migrate as well as the stream velocity and temperature that optimizes migration should enhance the survival of the smolts and increase salmonid recruitment. Increased chinook salmon and steelhead populations would also benefit commercial and recreational fisheries, their related economics and would maintain an integral part of the California Native American cultural heritage.

d. *Background and Biological/ Technical Justification:* Current uncertainty concerning the timing, velocity and temperature of water release from reservoirs to facilitate the migrations of wild stocks as well as the timing of the release of smolts from hatcheries prioritizes the need for in-depth studies on the process of smoltification. Comparable objectives cannot be obtained using other methods. This project incorporates powerful techniques for determining muscle performance and power in migrating fish.

This project is new, although recently our laboratory has initiated an investigation of steelhead growth, feeding and metabolic performance which is already funded. The basic premise of this project is supported by previous studies, including some from our laboratory using chinook salmon from the American River, which demonstrate a distinct increase in swimming performance before smoltification and then a decrease in swimming performance during smoltification. Other studies have demonstrated muscle fiber type changes associated with smoltification in Atlantic salmon (*Salmo salar*),a species with a life history type similar to the steelhead (Higgins, 1990;Higgens and Thorpe, 1990)

e. *Proposed Scope of Work:*

Year 1: Our existing flow table will be modified with the inclusion of increasing resistance flow-straightening elements to provide a velocity gradient. Velocities will be measured using an electromagnetic flow meter. The isometric muscle force/velocity apparatus will be constructed and calibrated following the design of Altringham and Johnston (1994). This will incorporate the thermostatted Ringer's saline bath, force transducer, and computer aided data acquisition system. The existing swimming flume will be modified by the inclusion of a rectangular plexiglass swimming chamber which will allow distortion-free videotaping of swimming smolts. The new chamber will be calibrated using the electromagnetic flow meter. Muscle histochemical techniques will be adapted from standard techniques on other species

(Batty, 1983; Dunn *et al.*, 1989; Squire, 1986; Sosnicki *et al., 1989*). Steelhead trout and fall-run chinook parr will be obtained from the Mokelumne hatchery in batches of 100 fish until immediately post smoltification (1-3 years). Preliminary data will be obtained from hatchery steelhead including flow table velocity preferences, muscle force/velocity measurements, critical swimming speed experiments, and muscle histochemistry.

Years 2 and 3: Juvenile chinook salmon and steelhead trout will be collected in the field. Experiments will include flow table velocity preferences, muscle force/velocity measurements, critical swimming speed experiments, and muscle histochemistry. This two-year commitment will elucidate year to year differences in fish condition and performance in the American River (Castleberry *et al.,* 1991). The results from these studies will be combined in manuscripts for submission to the appropriate scientific journals for review and publication. Magement recommendations will be formulated and sent to CDFG, DWR, USFWS, NMFS, and USBR decision makers for their consideration.

f. *Monitoring and Data Evaluation*

Quarterly reports will be sent to the CALFED Bay-Delta Program as well as to CDFG, USFWS, NMFS, and USBR for review. Once the data have been evaluated and statistically analyzed, technical manuscripts will be written and sent to a recognized journal for peer review and eventual publication.

Project results could be evaluated as soon as project recommendations are implemented (e.g., regarding the timing of water releases and smolt releases) by ongoing juvenile fish population monitoring programs (USFWS, CDFG, NMFS). The proposed study's results could also be used to support or help to explain the results current salmonid research such as projects on salmonid population dynamics and smoltification.

g. Implementablility

Extensive local support is available for the three year term of this project. Fish collection and hatchery fish will be provided by the Department of Fish and Game. University of California, Davis, is well known for its strong and diverse programs in biology. Seventeen professors at UCD are specialists in the field of fish biology. George Cardinet, a professor in the veterinary school, will be providing technical support for the histological studies. Steve Bennett in the Wildlife, Fish and Conservation Biology Department will be providing the hardware and software support. Further advice will be provided by scientists at the Department of Water Resources and the Department of Fish and Game who are currently working with our laboratory on research concerning water diversions and fish screens. Presentation of results will be made at appropriate workshops and professional meetings.

Technical advice regarding fish muscle contraction force/velocity has already been provided by a number of professors in the U.K. including John Altringham, Nancy Curtin and Geoffrey Goldspink. Technical instruction is also being provided by Ellen Freund in Professor Barbara Block's laboratory at Stanford University's Hopkins Marine Station.

Currently our laboratory is involved with a number of outreach programs for high school students and undergraduates. Our laboratory is involved with the UCD student American Fisheries Society which supports outreach programs such as lectures at local schools. At a local Junior High School in Elk Grove, Harriet Eddy Middle School, the students raise and release juvenile steelhead into local streams. The UCD student AFS chapter helps to transfer fertilized eggs as well as lecture about the local flora and fauna at the time of fish release. UCD also has a annual open house Picnic Day, in April, during which all the departments explain and display current research. A poster representing the results and goals of this project will be displayed annually at the Department of Wildlife, Fish, and Conservation Biology.

IV. Costs and Schedule to Implement Proposed Project

a. *Budget Costs*

Year 1:

Project Phase and Task	Personnel	Equipment	Supplies	Miscellaneous and other Direct Costs	Overhead	Total Cost
Critical Swimming Speed	6462.50	7000	N/A	2801	1000.75	17264.25
Flow Table	6462.50	5500	800	4001	1000.75	17764.25
Muscle Contraction	6462.50	9820	3000	1501	1000.75	21784.25
Muscle Histochemistry	6462.50	N/A	300	6302	1000.75	14064.25

Total costs for year 1: 70,879

Project Phase and Task	Personnel	Equipment	Supplies	Miscellaneous and other Direct Costs	Overhead	Total Cost
Critical Swimming Speed	6467.75	N/A	N/A	301	971	7739.75
Flow Table	6467.75	N/A	800	4001	971	12239.75
Muscle Contraction	6467.75	N/A	3000	1501	971	11939.75
Muscle Histochemistry	6512.50	N/A	300	6301	971	1484.50

Total costs for year 2: 47,230

Project Phase and Task	Personnel	Equipment	Supplies	Miscellaneous and other Direct Costs	Overhead	Total Cost
Critical Swimming Speed	6799.75	N/A	N/A	301	974.75	8075.50
Flow Table	6799.75	N/A	800	4001	974.75	12575.50
Muscle Contraction	6799.75	N/A	3000	1501	974.75	12275.50
Muscle Histochemistry	6799.75	N/A	300	6301	974.75	14375.50

Total costs for year 3: 47,302

b. *Schedule Milestones*
Milestones:

December 1997:	Project is funded Construction of variable velocity adaptations to the flow table and the rectangular swimming chamber for the Brett-type flume begins. Apparatus for measuring muscle force/velocity is built.
February 1998:	Equipment is calibrated and preliminary experiments carried out to perfect techniques.
April 1998	Steelhead and chinook parr are obtained from hatcheries and all laboratory experiments are conducted. Samples are collected for histological data.
May 1998	Transitional (parr to smolt) steelhead and chinook are obtained from hatcheries.and all laboratory experiments are conducted. Samples are collected for histological data.
June 1998	Steelhead and chinook smolts are obtained from hatcheries and all laboratory experiments are conducted. Samples are collected for histological data.

July 1998	Histological samples are analyzed.
November 1998	Submit annual report for 1988.
April 1999	Steelhead and chinook parr are obtained from the American River and all laboratory experiments are conducted. Samples are collected for histological data.
May 1999	Transitional (parr to smolt) steelhead and chinook are obtained from the American River.and all laboratory experiments are conducted. Samples are collected for histological data.
June 1999	Steelhead and chinook smolts are obtained from the American River and all laboratory experiments are conducted. Samples are collected for histological data.
July 1999	Histological samples are analyzed.
November 1999	Submit annual report for 1999.
April 2000	Steelhead and chinook parr are obtained from the American River and all laboratory experiments are conducted. Samples are collected for histological data.
May 2000	Transitional (parr to smolt) steelhead and chinook are obtained from the American River.and all laboratory experiments are conducted. Samples are collected for histological data.
June 2000	Steelhead and chinook smolts are obtained from the American River and all laboratory experiments are conducted. Samples are collected for histological data.
July 2000	Histological samples are analyzed. Results are compared between years for wild fish.
November 2000	Submit final report. Funding ends.

c. *Third Party Impacts*

We anticipate no negative third party impacts. We expect that the proposed studies will generate guidelines for stream temperature and flow criteria during smolt migration as well as a histological diagnostic tool for determining downstream migratory readiness. The implementation of these guidelines will result in enhanced smolt survival and increased salmonid recruitment. Increased chinook salmon and steelhead populations would also benefit commercial and recreational fisheries, their related economies and would maintain an integral part of the California Native American cultural heritage.

V. Applicant Qualifications

See next two pages.

JOSEPH J. CECH, JR.

EDUCATION

B.S. University of Wisconsin, Madison, 1966 (Zoology)
M.A. University of Texas, Austin, 1970 (Zoology)
Ph.D. University of Texas, Austin, 1973 (Zoology)

POSITIONS

Resident Zoologist, Sea Search I, R/V Dante Deo, Caribbean Sea and S. Pacific Ocean, 1965-66; Research Assistant, University of Texas Marine Science Institute, 1966, 1968-72; Teaching Assistant, University of Texas, 1967; Research Associate University of Texas Marine Science Institute, 1973; Research Associate, The Research Institute of the Gulf of Maine, 1973-1975; Lecturer, University of Maine at Portland-Gorham, 1975; Assistant Professor 1975-1981, Associate Professor 1981-1987, Professor of Fisheries Biology, University of California, Davis, 1987-present; Associate Editor, *Transactions of the American Fisheries Society*, 1991-1993; Chair, UC Davis Department of Wildlife, Fish, and Conservation Biology, 1992-1997.

AWARDS AND HONORS

NIH Predoctoral Fellow 1970-73; Member: Phi Sigma, Phi Kappa Phi, Sigma Xi; Invited participant: NATO Advanced Study Institute on "Environmental Physiology of Fishes", 1979, Lennoxville, Quebec; NATO Advanced Research Workshop on "Evolutionary Biology of Primitive Fishes", 1985, Bamfield, British Columbia; IUPS Discussion Panel on "Controversies: Circulation and Respiration", 1986, Vancouver, British Columbia; Organizer: 2nd Biennial International Symposium on "Fish Physiology, Toxicology, and Water Quality Management", 1990, Sacramento, California; Invited speaker: 3rd Biennial International Symposium on "Fish Physiology, Toxicology, and Water Quality Management, 1992, Nanjing, PRC; Fellow: American Institute of Fishery Research Biologists, 1992; Honorable Mention, Most Significant Paper in *Transactions of the American Fisheries Society*, Vol.121, 1992; Outstanding Faculty Adviser Award, College of Agricultural and Environmental Sciences: 1992-93; Plenary speaker, "High Performance Fish" First International Fish Physiology Symposium, Vancouver, Canada: 1994; Excellence in Fisheries Education Award (with P.B. Moyle), American Fisheries Society, 1995; Fellow: American Association for the Advancement of Science 1997.

SELECTED PUBLICATIONS (from >80 peer-reviewed articles and books)

Cech, J.J., Jr., Mitchell, S.J., Castleberry, D.T., and McEnroe, M. 1990. Distribution of California stream fishes: influence of environmental temperature and hypoxia. *Env. Biol.Fish.* 29:95-105.

Edwards, D.G. and J.J. Cech, Jr. 1990. Aquatic and aerial metabolism of juvenile monkeyface prickleback, *Cebidichthys violaceus*, an intertidal fish of California. *Comp. Biochem. Physiol.* 96A:61-65.

Cameron, J.N. and J.J. Cech, Jr. 1990. Lactate kinetics in exercised channel catfish. *Physiol. Zool.* 63:909-920.

Cech, J.J., Jr. 1990. Respirometry. pp. 335-362. In: C.B. Schreck and P.B. Moyle (eds.) Methods for Fish Biology. American Fisheries Society. Bethesda.

Sanderson, S.L., Cech, J.J., Jr., and Patterson, M. 1991. Fluid dynamics in suspension-feeding blackfish. *Science* 251:1346-1348.
Cech, J.J., Jr., R.G. Schwab, W.C. Coles, and B.B. Bridges. 1992. Mosquitofish reproduction: effects of photoperiod and nutrition. *Aquaculture* 101:361-369.
Sanderson, S.L. and Cech, J.J., Jr. 1992. Energetic cost of suspension feeding vs. particulate feeding in juvenile Sacramento blackfish. *Trans. Am. Fish. Soc.* 121:149-157.
Young, P.S. and J.J. Cech, Jr. 1993. Physiological stress responses to serial sampling and confinement in young-of-the-year striped bass, *Morone saxatilis* (Walbaum). *Comp. Biochem. Physiol.* 105A:239-244.
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Item 8

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME: Sandra M. Dowdy
Contracts and Grants Analyst

DATE EXECUTED: JUL 28 1997

EXECUTED IN THE COUNTY OF: YOLO

PROSPECTIVE CONTRACTOR'S SIGNATURE: Sandra M. Dowdy

PROSPECTIVE CONTRACTOR'S TITLE:

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

I-004038